# Investigating temporal trends in groundwater nitrate concentrations

## Situation

Nitrate is a drinking water concern for many Wisconsin communities and rural residents that rely on groundwater as their primary water supply. Wisconsin communities have spent upwards of $32 million on efforts to reduce nitrate in municipal water supplies. Many private well owners that undertake nitrate reduction efforts spend an average of $7,200 for a new well or $800+100/yr on water treatment [1]. Understanding whether nitrate concentrations are increasing or decreasing is of interest to water utility managers, private well owners, conservation professionals and those that enforce water quality standards.

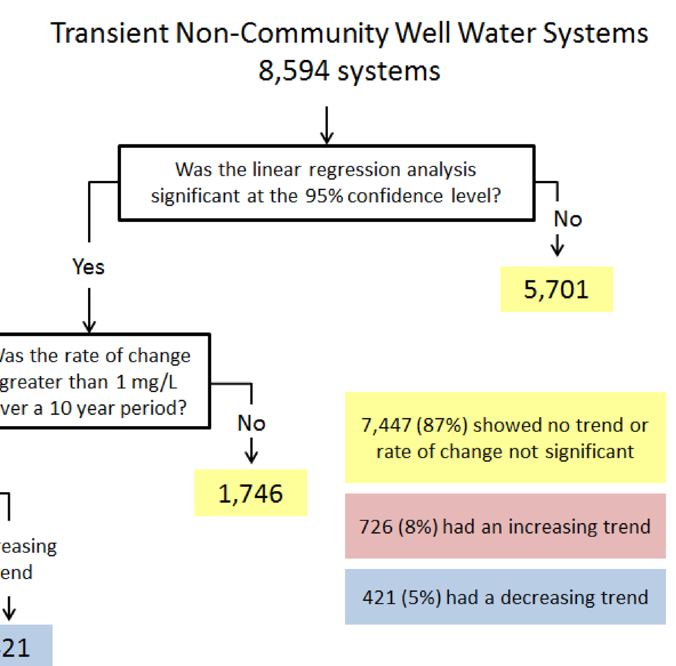
Natural concentrations of nitrate in groundwater are generally less than 1 mg/L. Elevated levels provide evidence that groundwater has been impacted by local land-use activities. Changes in nitrate often indicate changes in land-use or agricultural management practices. In an effort to focus resources in areas of most need and benefit, long-term monitoring of nitrate can be used to understand if groundwater quality has improved or declined.

Transient non-community water systems are required to regularly test water for nitrate. This existing long-term dataset provides a unique opportunity to evaluate temporal changes in shallow groundwater nitrate concentrations.

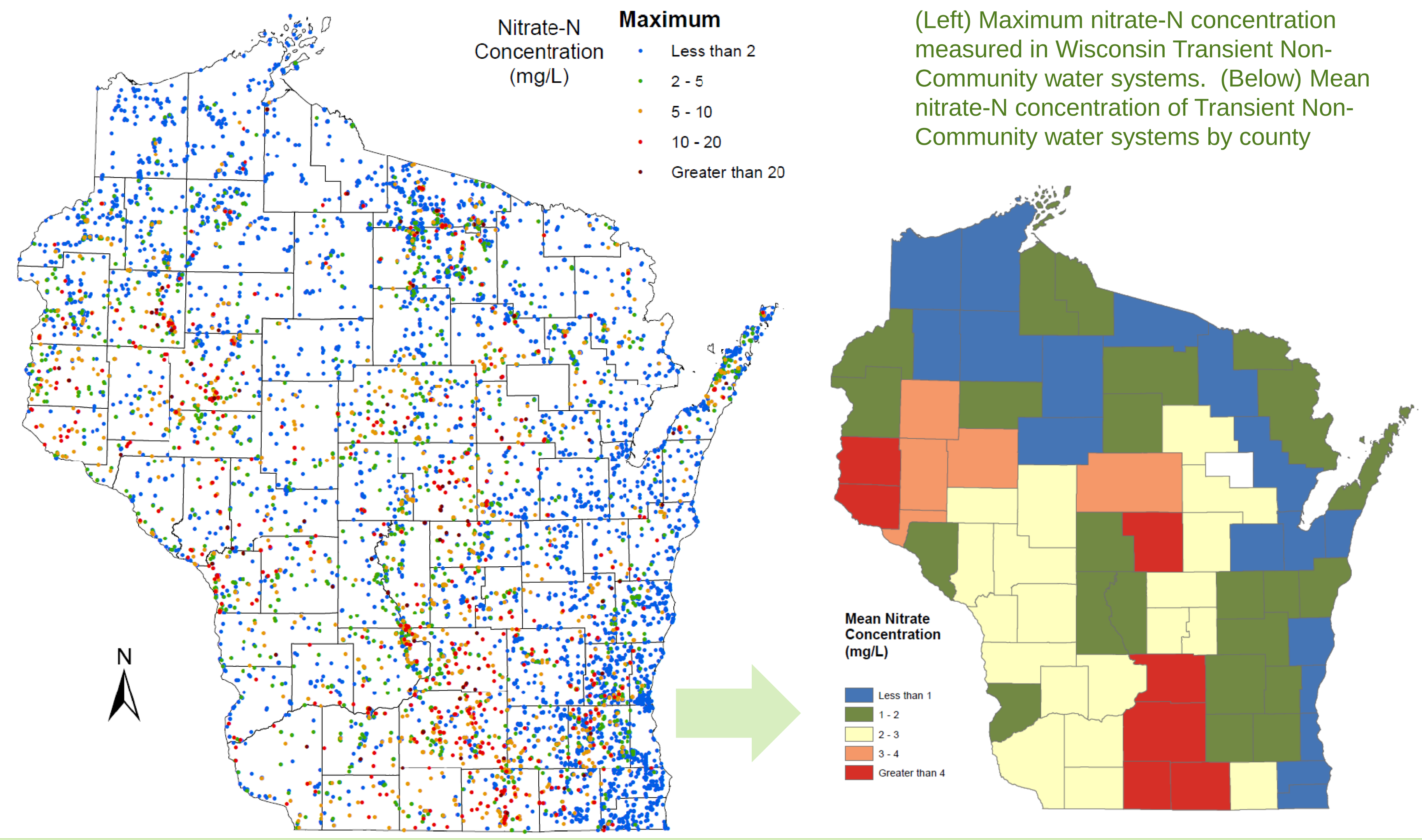
## Methods

- Nitrate data for nearly 8,594 Transient Non-Community (TNC) water systems (bars, restaurants, churches) with recent sampling and adequate frequency were compiled from the WI DNR Groundwater Retrieval Network.
- Linear regression analysis was performed on nitrate data from each individual TNC systems and evaluated for significance using the statistical program R.

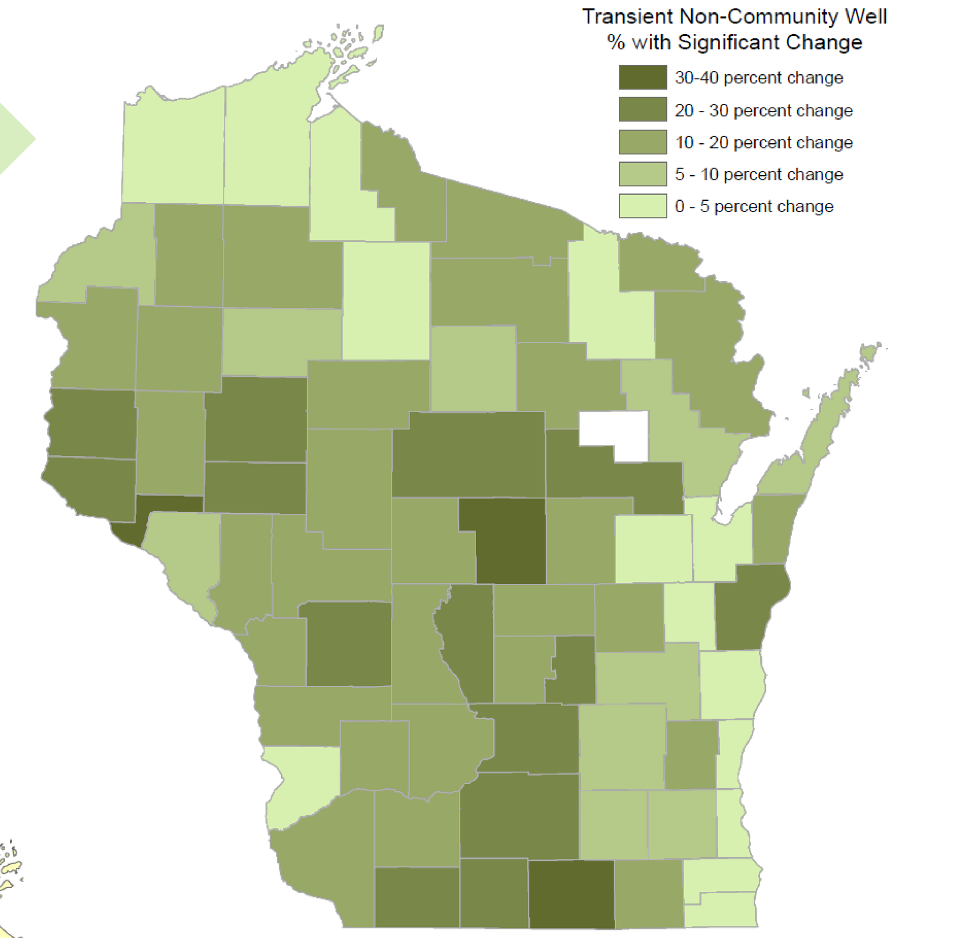
(Right) Increasing and decreasing time trends were determined using linear regression analysis and the slope which measured a rate of change. In our estimation, a rate of change less than 1 mg/L over a 10 year period did not constitute an increasing or decreasing trend.



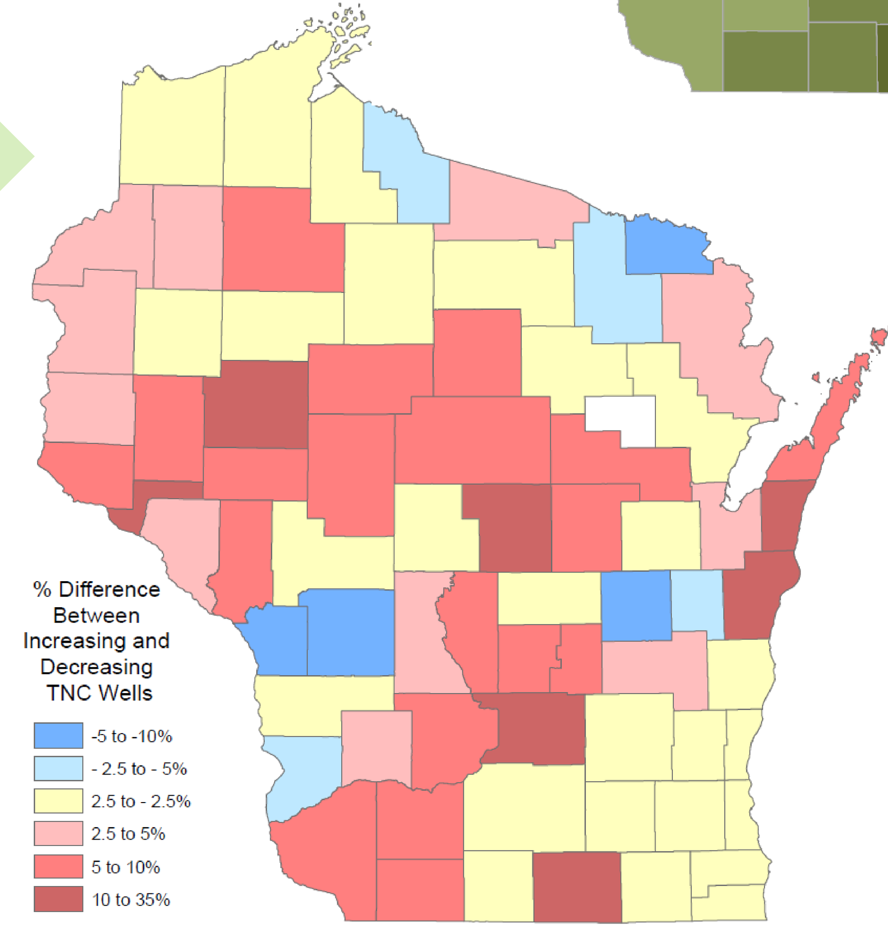

## Results



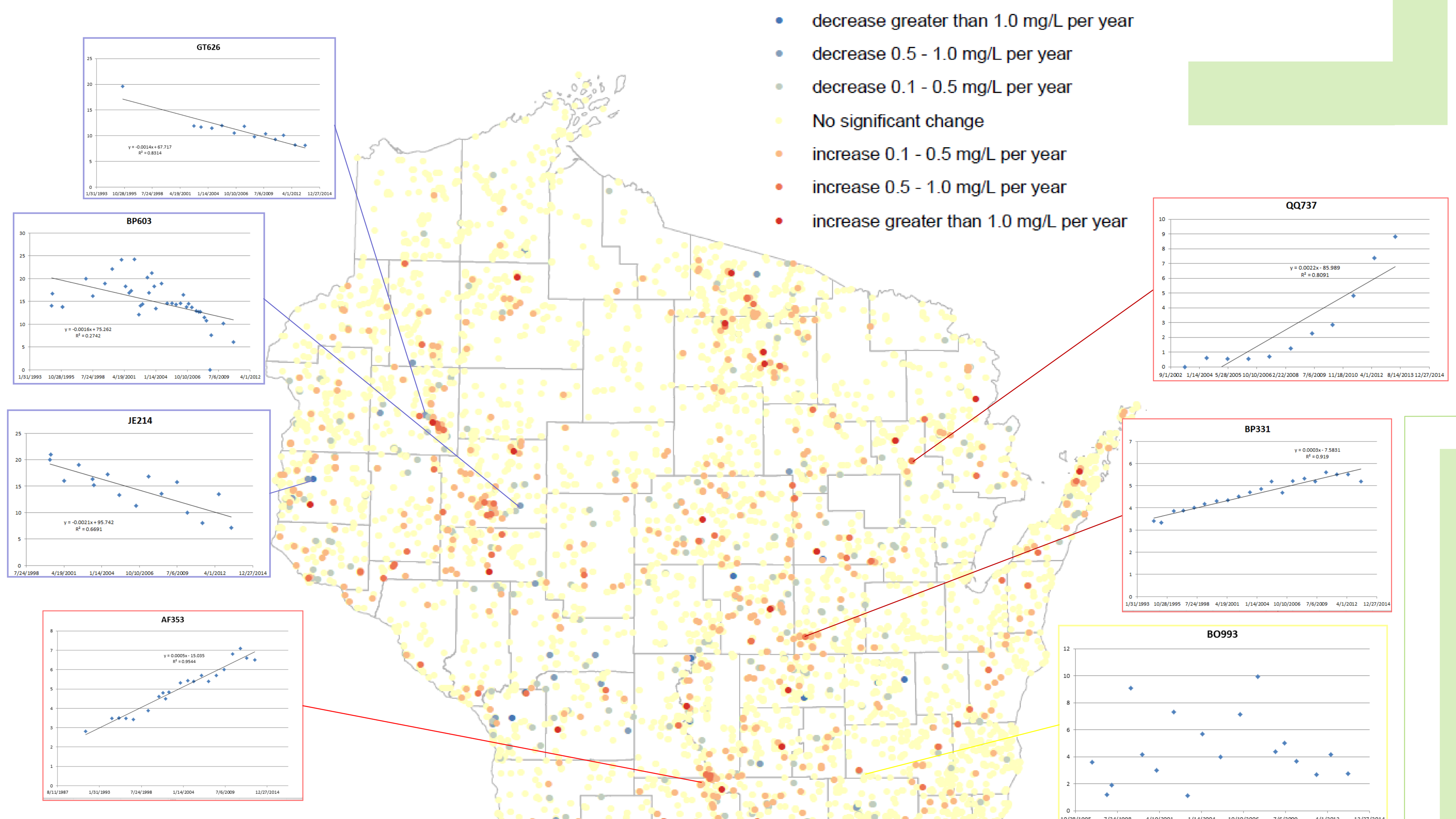

(Left) Maximum nitrate-N concentration measured in Wisconsin Transient Non-Community water systems. (Below) Mean nitrate-N concentration of Transient Non-Community water systems by county




(Right) Percentage of wells by county with an increasing or decreasing temporal trend.




(Left) Percent difference between increasing and decreasing wells by county (% Increasing - % Decreasing = % Difference). Red shades represent wells where a higher percentage have increased while blue represent counties where a higher percentage have decreased. Yellow counties indicate a small percentage that detected a change or similar numbers of increasing decreasing wells.




(Right) Results of linear regression analysis performed on TNC wells (n=8,594). If well determined to have a temporal trend the rate of change is indicated using red for increasing and blue for decreasing. Select wells used to show examples of increasing, decreasing, and no significant temporal trend (x-axis = date; y-axis = nitrate-N concentration in mg/L).

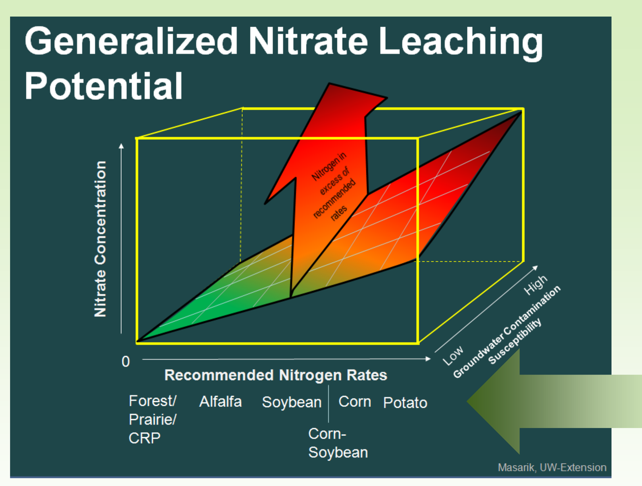
## Conclusions

While the temporal analysis indicates nitrate statewide has increased in more areas than decreased, the *shallow groundwater** accessed by 7,447 (87%) of TNC wells did not indicate a significant trend either way. Of the 13% wells with a temporal nitrate trend, 726 (63%) increased while 421 (37%) decreased. If these trends continue, it identifies 8% of TNC systems that may be required to invest in a new well and/or water treatment.

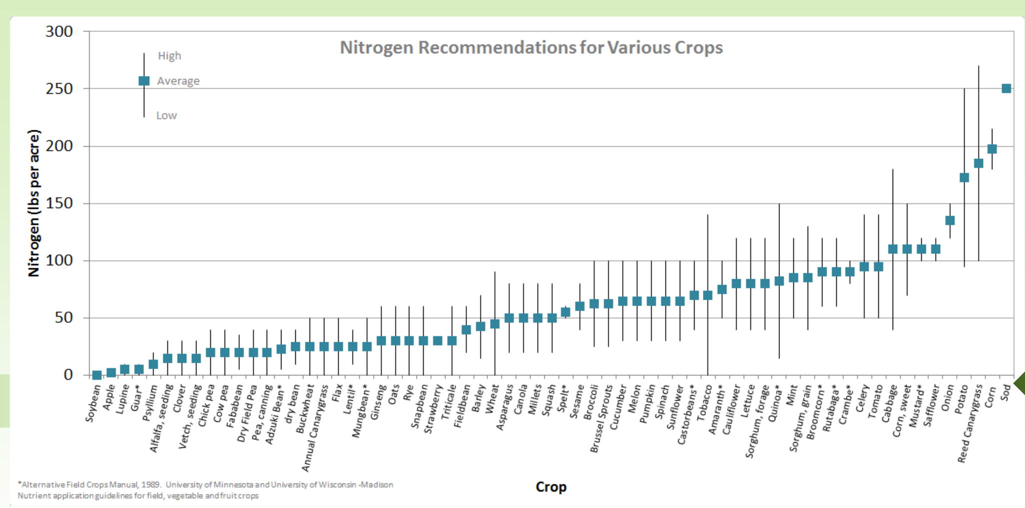
Additional investigation of the 1,147 wells with a temporal trend may help to identify the underlying causes of increasing or decreasing nitrate concentrations. The 5% of TNC systems that show a decreasing trend provide evidence that reduction of nitrate concentrations is possible for some wells within a meaningful time period. Understanding why concentrations in these wells have increased or decreased may help to prioritize strategies that result in measurable nitrate reduction.

**Please note the reference to shallow groundwater in our conclusions. These results should not be used to make conclusions about temporal trends in the nitrate concentrations of deeper groundwater aquifers accessed by deep municipal wells or of rivers and streams supplied by groundwater that may be decades or more old.*

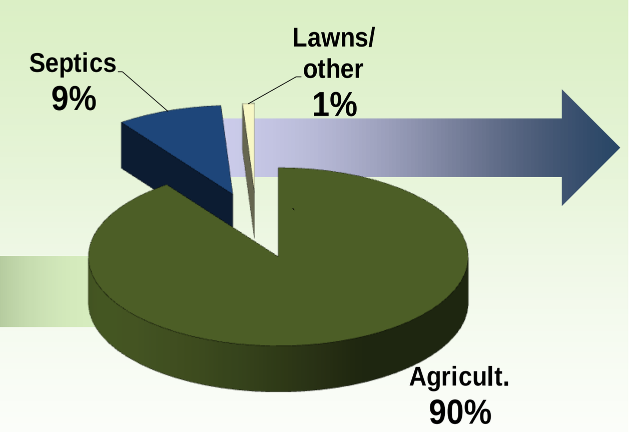
## Where does nitrate in groundwater come from?



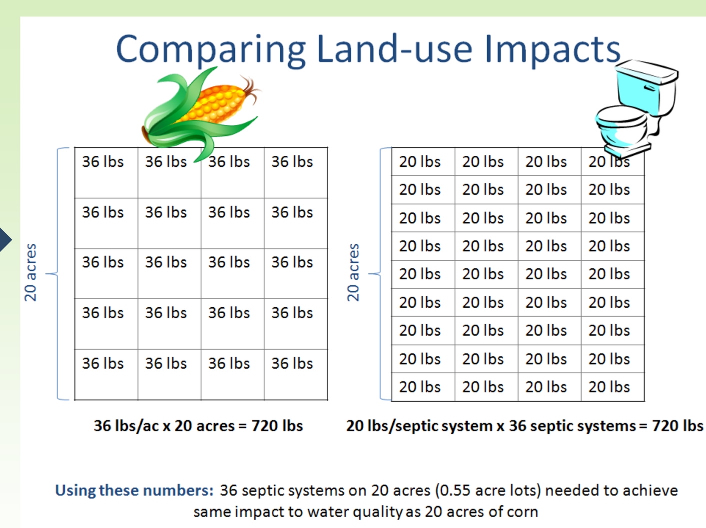

The amount of nitrate that leaches below a given field is related to both the type of crop grown and the local soils or geologic conditions [3]. The plane represents leaching potential (green = low, red = high) under various cropping systems and contamination susceptibility.




Crops have varying recommendations for nitrogen fertilizer application based on economic optimal yield curves established by fertility experts. While economically beneficial to apply at the rates seen above, not all of the nitrogen applied at these rates is taken up by the plant. Using the N difference method, it is estimated that in the Midwest only 37% of N fertilizer applied to corn is taken up by the plant [2].




Statewide agricultural inputs account for the vast majority of nitrate found in groundwater, followed by septic system and lawn care practices [4].




Elevated nitrate can sometimes be caused by densely developed areas with on-site wastewater treatment systems. Unless wells are directly down gradient of a septic plume, however, most septic systems do not cause widespread nitrate impacts to groundwater [5,6,7].


Kevin Masarik, UW-Extension & UW – Stevens Point, kmasarik@uwsp.edu
Junho Lee, Dept. of Statistics, UW – Madison
Jun Zhu, Dept. of Statistics/Dept. of Entomology, UW – Madison
Jeff Postle, Dept. of Ag., Trade and Consumer Protection
Jeff Helmuth, Dept. of Natural Resources
Randell Clark, Dept. of Natural Resources
Madeline Gotkowitz, WI Geological and Natural History Survey


**References:**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